TITLE: MEANS FOR COMPRESSING TUBES AND THE LIKE

TECHNICAL FIELD

This invention relates to devices and methods for use in compressing hollow flexible tubes to express matter contained therein. It is particularly, but not exclusively, suited to stripping blood from tubes that are connected to blood packs.

BACKGROUND

Our prior international patent application PCT/AU01/0400 disclosed devices and methods of this nature, with particular application for the stripping of blood lines. It also reviewed relevant prior art and the uses for such devices. Some of the devices disclosed in our prior application were hand-held and self-powered. This invention is particularly concern with further improvements to the design and operation of such devices.

The devices disclosed and illustrated in our prior patent application each had a pair of rollers that could be brought together to form a nip to pinch the tube and then rotated to draw the tube through the nip, thereby stripping or expressing the contents of the tube. If desired, the rotation of the rollers could be reversed and the tube driven in the opposite direction to allow it to fill with mixed blood and anticoagulant from the blood bag. After repeating the stripping and refilling steps one or two times, the full tube can be heat-sealed to form a sausages-string of sample pouches of blood that are very useful for use in cross-matching at a later date. Of course, at the end of the stripping procedure, the rotation of the rollers is stopped and the rollers are moved apart to allow the tube to be removed from the stripping device.

As is conventional in rolling mills and calendaring devices, the axes of the rollers of our prior application always remained in a plane that was orthogonal to the direction of travel of the material therebetween while the rollers are moved together and apart. We have now found that, in handheld tube-stripping devices where power is limited, undesirable strain and power consumption is involved when forming the nip, and/or it is difficult to obtain the desired pressure or gap between the rollers at the nip.

OUTLINE OF THE INVENTION

The present invention is based upon the realization that design and performance advantages in tube stripping devices, especially compact hand-held devices, if the roller movement that forms the nip is always at an angle to the plane that contains the axes of the rollers. For example, the angle between the roller movement and the plane of the roller axes when the nip is formed can be anywhere between about 30 degrees and 90 degrees. This is to be contrasted with conventional roller systems where the roller movement is always coplanar with the plane of the roller axes; that is, the angle between the direction of roller movement and the plane of the axes when the nip is formed is zero.

Thus, from one aspect, the present invention includes a device for expressing fluid from a tube by drawing the tube through the nip of a pair of rollers having spaced axes of rotation, one of the rollers being moveable toward the other to form the nip and away from the other to facilitate placement and removal of the tube from between the rollers, the device being characterized in that the moveable roller moves toward and away from the other in a direction that is at an angle to the plane that contains the axes of the rollers.

A tube guide may be used to guide the tube as it enters and or leaves the nip of the rollers and to assist in keeping the tube in the central portion of the nip. The tube is thus constrained to follow a defined path between the rollers and the guide when it is being stripped, and it is convenient to say that this path is 'longitudinal' with respect to the tube since the tube is flexible and will seldom be straight along its entire length.

Thus, from another aspect, the invention comprises a device for use in stripping fluid from a length of tube using rollers that can be brought together on opposite sides of the tube to form a nip between the rollers to compress the tube, at least one of the rollers being rotationally driven to draw the tube through the nip so as to expel fluid from the tube, the device being characterized in that the rollers are brought together to form the nip by moving one toward the other in a direction that has a longitudinal component with respect to the tube.

Conveniently, the rollers and the guide extend cantilever-fashion from the body of the device and one of the rollers is driven by first drive means and the other roller is allowed to idle, the idler roller being supported on mounting means that can be moved toward and away from the driven roller (to close and open the nip) by second drive means. The mounting means can be in the form of a yoke that straddles a drive shaft connected to the driven roller, the idler roller being rotatably mounted on one of the arms of the yoke and the second drive means being coupled to the other arm of the yoke to drive it so that the idler roller can be driven toward or away from the driven roller in the desired manner. One way of driving the yoke is to employ a leadscrew that engages with a nut in the respective arm of the yoke, the leadscrew preferably being rotated by a worm gear that forms part of the second drive means and mounted on a frame that is fixed relative to the body of the device.

DESCRIPTION OF AN EXAMPLE

Having broadly portrayed the nature of the present invention, one example of a device formed in accordance with the principles of the invention outlined above will now be described with reference to the accompanying drawings.

Brief Description of the Drawings

Figure 1 is and external plan view from above of the device of chosen example, the direction of view being indicated by arrow **I** on the end view of Figure 4.

Figure 2 is an external plan view from below of the device of Figure 1, the direction of view being indicated by arrow **II** on the end view of Figure 4.

Figure 3 is an external side elevation of the device of Figure 1, the direction of view being indicated by arrow **III** on the end view of Figure 4.

Figure 4 is an enlarged end elevation of the device of Figures 1 – 3 with the rollers shown in a partially open position.

Figure 5 is a reduced end view of the device of Figures 1 – 4 with the rollers in the closed position and a tube being pulled therethrough.

Figure 6 is a similar view to that of Figure 5 but shows a modified device with an alternative arrangement of rollers in the closed position.

Figure 7 is a general perspective of the mechanism of the device of Figures 1 – 5.

Figure 8 is an enlarged perspective of the mechanism shown in Figure 7, with some parts sectioned.

Referring generally to Figures 1 – 4, the device 10 of the chosen example is a self-powered, hand-held blood line stripper for use by blood collection agencies to effect the mixing of the anticoagulant contained in a full blood pack (not shown) with the residual blood in the blood line tube (not shown in Figures 1 – 4) so that sample pouches can be formed. [The procedure concerned was described in some detail in our prior application.] Device 10 has a two-piece molded body 12 comprised of left and right parts 12a and 12b, respectively, fitted together at joint line 13. Body 12 has a head or front portion 14 that houses the roller mechanism (to be described) and a tail or rear portion 16 that houses a battery (not shown or described herein). A pair of rollers 18 and 20 and tube guide 22 project forward cantilever fashion from the front face 24 of body 12 and connector means 26 are provided on the rear end 28 of rear portion 16 for the connection of a battery charger (not shown or described herein).

A pair of pads 30 and 32 are affixed to the top of device 10, as shown in Figure 1, to give the device a more comfortable grip for the user. The bottom of device 10, shown in Figure 2, has two pad-like switches 34 and 36 by which the device can be controlled, switch 34 having two positions for effecting the movement of rollers 18 and 20 together or apart, and switch 36 having one position for effecting the reversal of the roller rotation while switch 36 is operated. Figure 3 is a side view of the device showing side 12a in which a series of LEDs 38 indicate the level of charge of the battery. Figure 4 is an enlarged end view of device 10, showing rollers 18 and 20 in partially open, while Figure 5 is the same view (but reduced in scale) showing rollers 18 and 20 in the closed position and a tube 40 in the nip of the rollers. In Figure 5, arrow 42 indicates the direction of movement of tube 40 and arrows 44 indicate the direction of rotation of the rollers when device 10 is being operated as described below. It will be noted that guide 22 constrains tube 40 to move in a generally longitudinal direction, indicated by arrow 42.

The normal mode of operation of the device will thus be as follows: (i) device 10 is held in one hand, (ii) starting with rollers 18 and 20 apart, the tube 40 is placed in position between them and under guide 22 using the other hand, (iii) pad switch 34 is then operated by a finger of the first hand to close the rollers onto tube 40, rollers 18 and 20 being driven forwards (ie, in the direction of arrows 44) upon activation of switch 34 to close them so that, when closed, tube 40 is driven longitudinally (with respect to the tube) in the direction of arrow 42, (iv) upon reaching the blood bag or sealed needle-end of the tube, pad switch 36 is operated and held down to reverse the roller drive until the starting point is reached, (v) whereupon pad 36 is released and rollers 18 and 20 are again driven forwards, and finally (vi), when sufficient forward and reversing of the rollers had been effected, pad switch 34 is operated to open the rollers again, automatically effecting inactivation of the roller drive and allowing tube 40 to be removed from device 10. This mode of operation is substantially as disclosed in our prior patent.

In this example, roller 18 is mounted fixedly relative to body 12 of device 10 and is driven by first drive means (to be described), while roller 20 is an idler roller that is moveable within body 12 toward and away from fixed roller 18, the direction of movement being vertical, that is, parallel with the joint 13 between the two halves 12a and 12b of body 12 and generally longitudinal with respect to the tube (when in place, as in Figure 5). The direction of the movement of roller 20 is also indicated by a vertical slot 50 formed in the front face 24 of the device to accommodate the shaft of roller 20 is it moves. From Figure 5 it will be seen that the movement of tube 40 during stripping is nearly vertical (in part because of the constraining action of guide 22) and that idler roller 20 moves roughly parallel (ie, longitudinal) with tube 40 during opening and closing of the nip with roller 18. In Figure 5, the nip and pinch-point in the tube are coincident and indicated at **X**. The roller movement contrasts sharply with conventional pinch-rolls (including those described in our prior patent application) where the movement of the roller(s) in forming the nip is orthogonal to the general direction of travel of material through the rolls and to the direction of travel at the pinch point.

In the arrangement of Figure 5, rollers 18 and 20 overlap when viewed in the direction of travel of roller 20 (ie, vertically – see Figures 1 and 2) so that, when the

nip **X** is formed, the plane or line **Y** that passes through the axes of the rollers is at a significant angle θ – about 45 degrees in this case – to the movement of roller 20 as indicated by slot 50. In our experience, angles much smaller than this are undesirable, though angles as high as 90 degrees are possible, as illustrated by Figure 6.

Figure 6 shows a modified device 10a that has rollers 18a and 20a that do not overlap at all when viewed in line with the direction of movement of roller 20a, making angle θ 90 degrees. Thus, as indicated by the vertical orientations of slot 50a and arrow 42a, tube 40a travels essentially parallel with the movement of roller 20a (ie., vertically in this case). However, the geometry of Figure 6 may not be optimal because the pinch pressure cannot be adjusted by movement of a limit switch (not shown) that controls the position of the moving roller in the closed position.

It is important to note that the direction of movement of moveable roller 20 or 20a is never coplanar with the plane **Y** defined by the axes of the two rollers 18, 18a and 20, 20a, whether the rollers are open or closed. This contrasts with the prior art where the direction of movement of the moveable roller is always coplanar with the axes of the two rollers. While Figures 5 and 6 show arrangements where the angles between the direction of movement of the moveable roller and the plane of the roller axes are, respectively, about 45 and 90 degrees when the nip is formed, we have found that angles between about 30 degrees and 90 degrees can be used with advantage.

Turning now to Figures 7 and 8, the mechanism associated with rollers 18 and 20 will now be described, some portions of the mechanism being cut away or omitted in Figure 8 for the sake of clarity. Fixed and driven roller 18 is attached to a shaft 60 that is driven directly by a low-voltage electric motor 62 via an integral planetary gearbox 64, which are mounted on front portion 66a of frame 66. Thus, in this example, shaft 60, motor 62 and gearbox 64 comprise the first drive means referred to above. The front portion of shaft 60 is supported for rotation in a bearing 68 that is mounted in a front portion 66a of frame 66. Idler roller 20, however, is mounted for free rotation on a short shaft or stub axle 70 that is rigidly attached to the bottom

of one arm 72a of a moveable yoke 72 located for vertical sliding movement in frame 66. In Figure 8, roller 18 has been cut away to show shaft 70 and the lower portion of yoke arm 72a more clearly.

Yoke 72 is driven up and down by means of a vertical leadscrew 74 that engages a nut 76 fixed in the top of yoke arm 72b, which is bored to take leadscrew 74. The top of leadscrew 74 is mounted for rotation in a bearing 76 fitted into a horizontal plate 66b that forms part of frame 66, the lower portion of leadscrew 74 being rotationally and slidingly located by a bearing 78 that is mounted in the bottom part of yoke arm 72b and retained there by a circlip 80. A worm-wheel 82 is fixed to leadscrew 74 below yoke arm 72b, the lower extremity of leadscrew 78 being mounted for rotation in a bearing 84 fitted in a lower horizontal plate 66c of frame 66. Worm-wheel 82 is engaged by a worm 86 that is mounted on a horizontal shaft 88 that is driven by a second low-voltage motor and gearbox assembly 90, the front end of shaft being located in a bearing (not shown) located in front element 66a of frame 66. Thus, in this example, the second drive means can encompass motor 90, shaft 88, worm and gear 86 and 82 and leadscrew 74 and nut 76, either in their entirety or in part.

It will be seen that rotation of shaft 88 by motor 90 in one direction or the other will effect the rotation of leadscrew 74 in nut 76 (via worm drive 82/86) and cause yoke 72 to be driven up or down, carrying idler roller 20 with it. The slot 50 in frame 66a (visible in front face 24 of device 10) permits this movement, as already noted. Though not shown in the drawings, it is desirable that both the up and down movements of yoke 72 be set by limit switches connected in the power circuit to motor 90. This technique is well known in the art and can be used to effect fine adjustment of the upper limit of travel of roller 20 to set the roller nip **X** to the desired gap. It will also be seen that, because shaft 60 (by which fixed roller 18 is driven) passes through the central opening 92 of yoke 72, it and roller 18 are free to rotate whatever the position of the yoke. [As shown in Figure 8, yoke 72 and roller 20 are near the lower limit of their travel.]

While the above example illustrates a device that is particularly useful for stripping blood lines, it will be appreciated that disclosed principle of roller movement can

have application elsewhere and that many changes can be made to this example without departing from the scope of the mechanism as defined by the following claims. For example, the device need not be battery powered as power can readily be supplied to the drive means via a trailing electrical lead.

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